AD-A114 350 CONTROL DATA CORP MONTEREY CA F/G 8/12
FUNCTIONAL DESCRIPTION FOR MODIFICATION OF THE POLAR ICE FORECA--ETC(U)
OCT 81 P A HARR, T C PHAM N00014-81-F-0028
UNCLASSIFIED NORDA-TN-120 NL

1 OF 1
AD
A114350

END
DATE
FILMED
6-82
DTIC

(13)

NORDA Technical Note 120

Naval Ocean Research and
Development Activity
NSTL Station, Mississippi 39529

Functional Description for Modification of the Polar Ice Forecast Subsystem - Arctic

P.A. Harr
T.C. Pham
Control Data Corporation
Monterey, California

Prepared for:

Oceanography Division
Ocean Science and Technology Laboratory

October 1981

ABSTRACT

This document describes a modified dynamic thermodynamic model to forecast Arctic sea ice conditions. Included are: (1) system requirements, (2) performance requirements, (3) preliminary design, and (4) user/developer impacts especially fixed and continuing costs.

TABLE OF CONTENTS

SECTION 1.0 GENERAL

1.1 Purpose of Functional Description

This Functional Description for the dynamic thermodynamic sea ice model is written to provide:

a) The system requirements to be satisfied which will serve as a basis for mutual understanding between the user and the developer.

b) Information on performance requirements, preliminary design, and user impacts, including fixed and continuing costs.

c) A basis for the development of system tests.

1.2 Project References

A dynamic-thermodynamic sea ice model was developed by Dr. W. D. Hibler III of the United States Army's Cold Region Research laboratory. This model computes ice drift, concentration and thickness from atmospheric wind and ocean current data.

A contract was awarded to Control Data Corporation by NORDA's Polar Oceanography Branch, Bay St. Louis, MS, Solicitation No. N00014-81-F0028 for software additions to the Hibler model which will perform the following functions:

i) Bring the storage requirement of the Hibler model within guidelines specified by Fleet Numerical Oceanography Center (FNOC).

ii) Modify the model to accept FNOC environmental data as input.

iii) Make runs with FNOC data.

iv) Complete adaption of input/output codes to run on CDC 6500 at FNOC.

v) Commence coding for the Hibler model to run on CYBER 203 at FNOC.

vi) Collect and prepare data for input with specified boundary conditions to run the modified Hibler model on the CYBER 203.

A number of sea ice models have appeared in the literature in recent years. A list of references applicable to this model is presented below:

Hibler, W. D., 1980: Modeling a Variable Thickness Sea Ice Cover, Mon. Wea. Rev., 108, 1943-1973.

Prittchard, R. S., 1978: The Effect of Strength on Simulation of Sea Ice Dynamics. Proc. Fourth Int. Cong. Prot. and Ocean Engineering under Arctic Conditions, D. KE. Muggeridge, Ed., Memorial University of St. Johns, Newfoundland, 494-497.

M. D. Coon and M. G. Phee, 1977: Simulation of Sea Ice Dynamics During AIDJEX, J. Prep. Vessel Tech., 99J, 491-497.

Thorndike, A. S., and R. Colony, 1980: Large-Scale Ice Motion in the Beaufort Sea During AIDJEX, April 1975 - April 1976. Sea Ice Processes and Models, R. S. Prittchard, Ed., University of Washington Prep., 249-260.

The following standards and reference documentation will be used as guidelines:

i) DoD Manual Standard 7935.1-S of 13 September 1977, "Automated Data System Documentation Standards".

ii) FNOC Computer Users Guide.

iii) NOS/BE, Reference Manual, Control data Corporation, 7/76.

iv) FORTRAN Extended Version 4, reference Manual, Control Data Corporation, 4/77.

v) CDC CYBER 200 Fortran Language 1.5, Reference Manual, Control data Corporation, 1980.

vi) CDC CYBER 200 Operating System Version 1, Control Data Corporation, 1980.

SECTION 2.0 System Summary

2.1 Background

Fleet Numerical Oceanography Center (FNOC), in Monterey, CA is responsible for producing operational forecasts of environmental parameter and conditions throughout the world. This contract and report deals with the Arctic Ocean region. FNOC has currently been using an Arctic sea Ice model (e.g., SKILES) which is based on an emperical relationship derived between the ocean current, atmospheric wind and sea ice movement. This model is used to calculate a simulated ice drift for the entire northern hemisphere extending from the pole to 40N latitude. Simulated drift vectors are calculated at FNOC grid points, whether ice is currently existing there or not.

This model provided an initial response to a validated need of quality forecast information pertaining to sea ice conditions in the arctic. However, the quality of the forecast drift vectors is suspect.

The operational requirements of the Naval Polar Oceanography Center (NPOC) were not being satisfied by the use of this limited model. However, two additional, more complete models had been developed for simulating sea ice conditions in the Arctic. One model, developed by Dr. Hibler, developed a model which simulates sea ice distribution and drift throughout the Arctic Basin. Another model, developed through the Arctic Sea Ice Dynamics Joint Experiment (AIDJEX), has been used to simulate ice conditions in a more limited area.

Conclusions were drawn which stated that the use of these two models could potentially satisfy the operational needs of NPOC. Initial thoughts lead to tasks which

would require the mutual operation of the two models on the FNOC computer system. An evaluation of the model's performance would be used to choose a final operational model. However, further discussion lead to the discovery that the models are actually incompatible and an intercomparison of results would be totally unrealistic.

Results of a meeting held in June, 1980 at the Naval Ocean Research and Development Activity (NORDA) lead to the following conclusions. An Arctic Basin Model (PIFS-N) would be used at FNOC. This model would be a version of the model developed by Dr. Hibler. A similar model would be developed for the Antarctic (PIFS-S). A third model that will be regionally utilized will also be available at FNOC. This model will be a version of the AIDJEX model. The basin model will run for forecasts up to 7 days utilizing 24 hour time steps.

The work described by this Functional Description is intended to help in the development of the PIFS-N model.

2.2 Objectives

The objectives of the current effort are stated as follows:

i) Finalization of the Hibler model on the CDC 6500 at FNOC.

ii) Operation of the Hibler model on the CDC CY203 at FNOC.

iii) Preparation of data, for input to the model, from the FNOC data base, on the CY203.

iv) Prepare a) Users Manual, b) Operations

Manual, and c) Maintenance Manual for the model.

v) Perform a long term simulation and evaluate the results with actual data.

These objectives were specified after intial work was performed by Control Data resulting in the satisfaction of the following requirements:

i) The Hibler model was restructured to meet FNOC storage requirements on the CDC 6500.

ii) Sample runs were made utilizing predefined atmospheric and ocean current data.

2.3 *Existing methods and Procedures*

FNOC is currently supplying arctic sea ice forecasts through the use of the SKILES model. This model derives sea ice drift based on an empirical relationship, based on an Ekman boundary, between atmospheric winds, ocean currents and ice drift. No thermodynamic terms are included, therefore no information is conveyed concerning the ice thickness concentration or growth. The current model operates on a grid which extends from the North Pole to 45N latitude. Ice drift vectors are computed at FNOC grid points at all run times, whether ice currently exists at the at the location or not.

The SKILES model is run on the operational machines at FNOC which are CDC 6500s. Input, surface pressure, data is received from the FNOC data base. Ocean current data is held internal to the model. Drift vector information is plotted at FNOC for the NEDN system. Printed messages are also relayed through the AUTODIN network to fleet users. The main

receiver of the SKILES output is NPOC. Figure 1 illustrates the data flow for the existing system.

2.4 Proposed Methods and Procedures

The proposed solution to the problem of inadequacies in the SKILES model involves the replacement of the model with a more sophisticated one, which will operate over the same geographic area. The dynamic-thermodynamic model developed by Dr. Hibler has been chosen to replace the SKILES model.

The new model will operate on the CY203 at FNOC. Operational forecasts will be made of the following variables:

i) ice drift;
ii) ice thickness;
iii) ice concentration;
iv) ice growth;
v) ice strength;
vi) open water growth;
vii) ice divergence.

Forecasts will be produced out to 7 days utilizing 24 hour time steps.

The model is more complete than the SKILES model. A heat budget is included, to provide information concerning the thermodynamic of the ice, which is dependent upon the time of year. The new model will depend more heavily, upon the FNOC data base for several environmental data fields used in the heat budget calculations.

The momentum equations, used to simulate ice drift are based upon known physical concepts. The efforts of atmospheric and oceanic drag are considered while the ice behaves as a plastic medium. Figure 2 illustrates the data flow for the proposed system. Comparison of this figure with figure 1 illustrates the major differences in the two systems.

Details of the model structure are provided by Hibler (1979).

The new model will be designed to operate within three phases or modules. An input module will access the FNOC data base. Atmospheric data will be utilized from this data base for each time step. This data will be used in the ice drift and thermodynamic calculations. The input module will also access a user designated file which shall supply controlling information to the model. A processing module will perform the actual calculations required to integrate the equations in time. An output module will maintain a database on the CY 203 which will contain resultant forecast fields.

The model system will interface with other machines through these data bases. Input data will be transferred to the CY203 from machines holding this data. Likewise, output files will be transferred from the CY203 to machines capable of producing the required output VARIAN plots.

2.4.1 Summary of Improvements

The new sea ice model system is designed to provide more complete and detailed forecast information of arctic sea ice conditions in an operational time frame.

It is hoped that the model will provide more accurate ice drift forecasts plus forecasts of ice thickness, concentration, growth/decay and strength. The model system

shall utilize more environmental data to provide timely input to the compytational procedures which shall describe the current state of the atmospheric/ocean system in the forecast area.

The model will also utilize the CY203 at FNOC, providing quicker processing than on other machines.

2.4.2 Summary of impacts

2.4.2.1 Equipment Impacts

The sea ice model will operate on the CY 203 at FNOC. Interfaces shall transfer data between the CY203 and the Cy170/720 (front-end) and the CY175 (SPC). No additions or modifications to the existing equipment at FNOC are required.

2.4.2.2 Software Impacts

The sea ice model utilizes the standard products subroutine library at FNOC, FNWCLIB. The model also interfaces with the FNOC maintained CRANDIC, ZRANDIC, FTU, and VARIAN software packages.

The major software impact shall be the modification of the FTU input cards for specifying that required input fields of the model be transferred to the CY203 and appropriate output files of the model get trasnferred to the SPC for VARIAN processing.

2.4.2.3 Organizational Impacts

Interaction between the three main organizations, FNOC, NPOC, and NORDA, will probably be required during initial operation of the sea ice model. It is anticipated that NPOC will carefully examine initial forecasts and interact with FNOC and NORDA regarding any further modifications thought necessary for a good product.

2.4.2.4 Operational Impacts

The sea ice model will need to be placed within the operational job stream at FNOC. A number of files will have to be operationally transferred between machines. This will require attention of the watch personnel in order to validate file transfer as the model will not operate without correct data. Data will need to be retained until the current run is completed.

Minimal input is anticipated on the procedures of the operational staff beyond data handling during initial runs.

Approximately 150 sec of CY203 time would be required to integrate the model for the required 7 days.

2.4.2.5 Development Impacts

No major impacts are anticipated during development of the sea ice forecasting system. All required data bases are maintained at FNOC through standard procedures.

SECTION 3.0 Detailed Characteristics

3.1 System Performance Requirements

The sea ice model is required to produce up to 7 day forecasts of the following parameters;

i) ice drift;
ii) ice thickness;
iii) ice concentration;
iv) ice growth;
v) open water growth;
vi) ice strength.

The model system shall provide these forecasts in terms of straight forward and concise graphical displays.

3.1.1 Accuracy and Validity

Validity and accuracy of the sea ice model will be tested by analysis of a 5 year simulation run utilizing statistical techniques. Simulated buoys will be drifted throughout the grid with portions compared to actual buoy locations during the same period.

Dr. Hibler (1979) presented results showing good agreement between simulated and actual data parameters in the Arctic Ocean.

3.1.2 Timing

The sea ice model will require approximately 25 seconds per time step (one day) on the CY203.

3.2 System Functions

The sea ice model will supply forecasts of selected Arctic ice parameters out of 7 days. The specific forecast fields will be plotted for use by NPCC and their respective users.

3.3 Inputs - Outputs

Specific atmospheric data records, obtainable from the FNOC data base, are required input for the model. The following data fields are needed;

i) Surface pressure;
ii) U, V wind components (surface);
iii) surface air temperature;
iv) incoming short wave radiation;
v) total heat flux;
vi) sensible plus evaporative heat flux.

An input file will be specified by the user to define the following control information;

i) model grid size;
ii) model grid location with respect to the

FNOC hemispheric grid;

iii) number of time steps to be run;

iv) boundary masks.

An output file shall be maintained by the model. This file will contain forecast fields of parameters described above in Section 3.1.

3.4 Data Characteristics

The user defined data file will be a binary file which can be accessed by a normal FORTRAN READ function.

The FNOC input and model output file will be a CRANDIO file. CRANDIO is the format required for all operational data files maintained on the CY203. CRANDIO is equivalent to the ZRANDIC system on other FNOC machines.

3.5 Failure Contingencies

The main source of failure of the sea ice model will be invalid handling of input or output data. If required data is missing or output data is not properly defined for CRANDIC the model will fail. Corrective measures for these types of failures are outlined in detail in the CRANDIC software documentation maintained by FNOC.

The model may be restarted by reading the output file of the previous run. This allows for simulations to be interrupted before the required number of time steps are completed.

SECTION 4.0 Environment

4.1 Equipment Environment

FNOC operates a multi-programming/multi-mainframe computer system consisting of a CYBER 203 with 1 million 64 bit words of central memory and a CYBER 720 as its front-end, three CDC 6500's with 131K CM each, and related equipment.

4.2 Support Software Environment

FNOC operates under the NOS/BE operating system. The modified Hibler model uses many routines from the FNOC library.

4.3 Interfaces

The modified Hibler model gets atmospheric and oceanic data from MASFNWC file for input. It stores output in the master file for plotting and distribution over NEDN system to NPOC.

4.4 Security and Privacy

The user is responsible for protection of any material used by the model. It is up to FLENUMOCEANCEN, and NPOC to decide whether it should be classified.

SECTION 5.0 References

Hibler, W. D. III, 1979: A Dynamic Thermodynamic Sea Ice Model. J. Phys. Oceanogr., 9, 815-846. 1980: Modeling a Variable Thickness Sea Ice Cover. Mon. Wea. Rev., 108, 1943-1973.

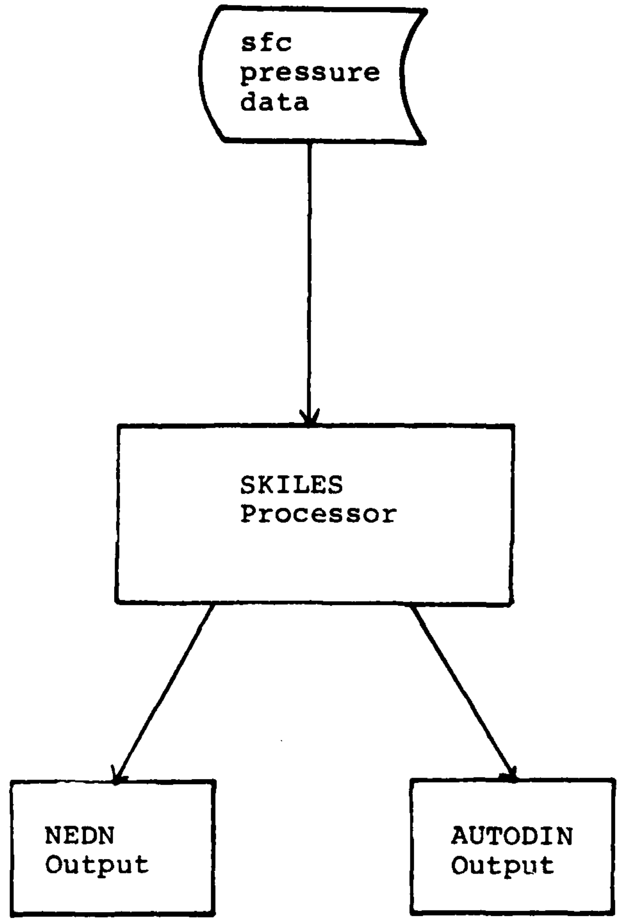

Figure 1   Data Flow for SKILES Model

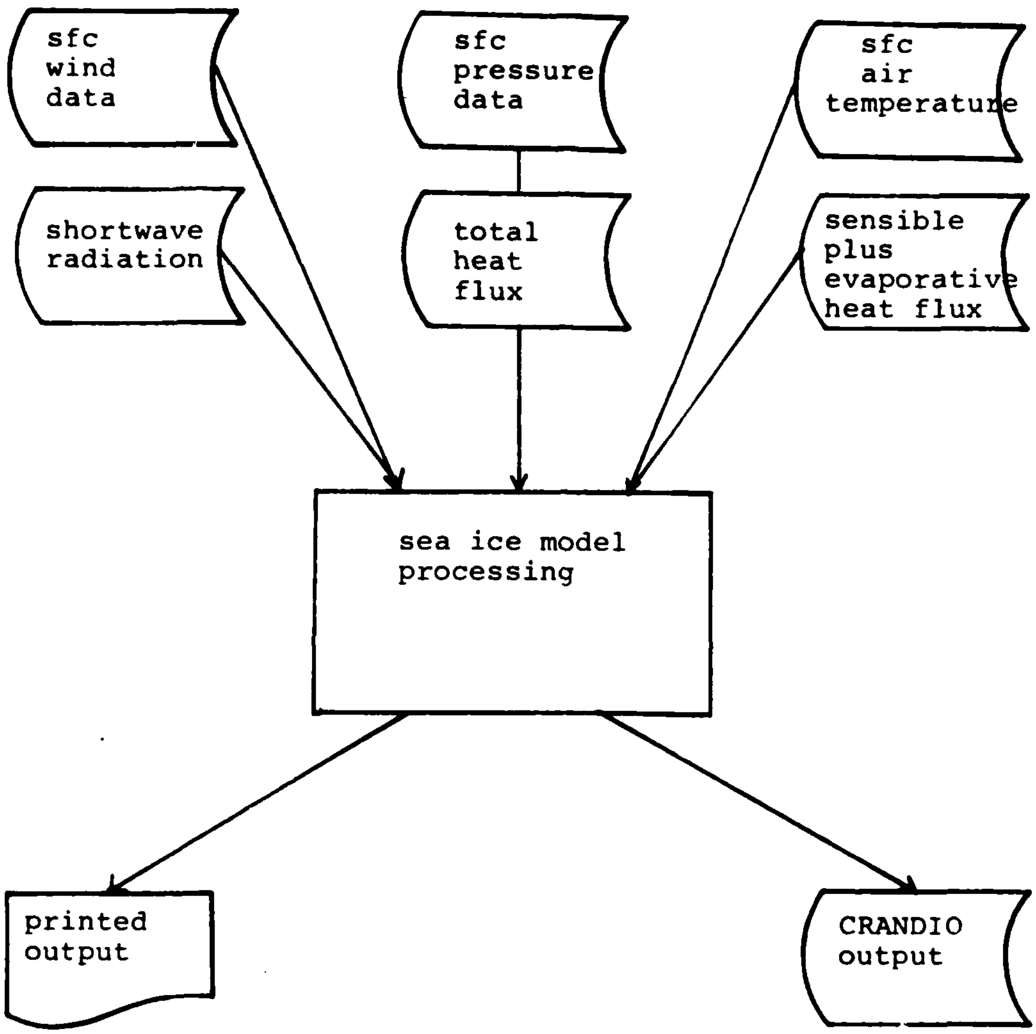

Figure 2 Data Flow for Sea Ice Model

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NORDA Tech Note 120	2. GOVT ACCESSION NO. AD-A114 350	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Functional Description for Modification of the Polar Ice Forecast Subsystem - Arctic		5. TYPE OF REPORT & PERIOD COVERED Final FY81 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. A. Harr and T. C. Pham		8. CONTRACT OR GRANT NUMBER(s) N00014-81-F-0028
9. PERFORMING ORGANIZATION NAME AND ADDRESS Control Data Corporation 205 Montecito Ave. Monterey, CA 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 93321D work unit
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Jefferson Davis Highway Arlington, VA 22210		12. REPORT DATE October 1981 13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Polar Oceanography Branch NORDA NSTL Station, MS 39529		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Numerical model
Polar
Ice Forecasting
Sea Ice
Arctic

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document describes a modified dynamic thermodynamic model to forecast Arctic sea ice conditions. Included are: 1) system requirements, 2) performance requirements, 3) preliminary design, and 4) user/developer impacts especially fixed and continuing costs.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

END

DATE
FILMED

5-82

DTIC